PROJECT MANAGEMENT

18ME653 –PE3

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BOOKS

1. S Choudhary, "Project Management" Tata McGraw Hill Education Private Limited New Delhi.

2001

2. Harold Kerzner, "Project Management: A Systems Approach To Planning, Scheduling And Controlling ", CBS publisher and distributers

3. **L S Srinath " PERT and CPM Principles and Applications" Third Eddition**

4. **Dr. P N Modi "PERT and CPM"**

Tools and techniques of project management

- Manager or admittatur constantly for looks forward to those techniques or methods which helps him in
- Planning
- Scheduling
- Controlling such activates
- The concept of network planning and critical path analysis
- It is technique through which largerer projects are broken down to individual jobs or events and arranged in logical Network
- PERT and CPM are two management techniques.

Unit-4.Sheduling Techniques

- 1. Gantt charts
- 2. Milestone charts
- 3. Work break down structure
- 4.PERT and CPM Networks

Gantt Chart

Preparing a pattern for casting	4 weeks
Preparing a mould	2 weeks
Casting and cleaning operation of *A*	1 week
Heat-treatment of *A*	2 weeks
Obtaining and installing machine *M*	7 weeks
Machining part *B*	5 weeks
Assembling parts *A* and *B*	3 weeks
Preparing the test rig	4 weeks

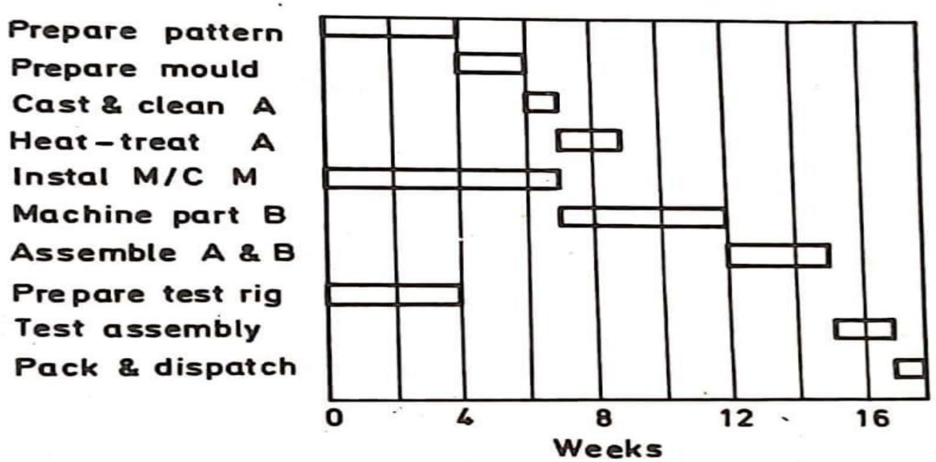

FIGURE 1-2

MILESTONECHARTS AND WORK BREAKDOWN STRUCTURER

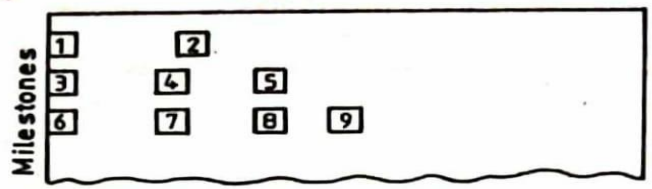

FIGURE 1-6

interdependencies between events. In a milestone chart, the events are in chronological, but not in a logical, sequence. A natural extension of the milestone chart was the network, where the events are connected by arrows in a logical sequence. This is shown in Fig. 1-7.

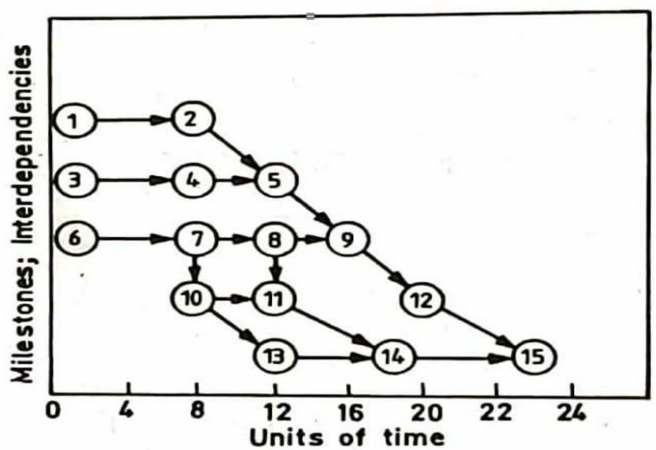

FIGURE 1-7

... planning and control.

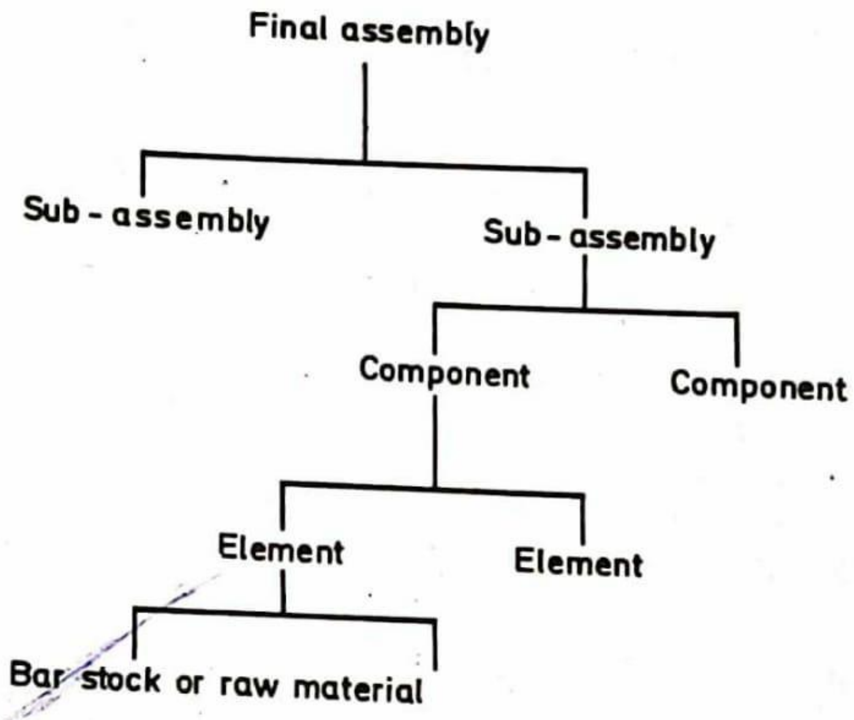

FIGURE 1-8

The several units in the ...

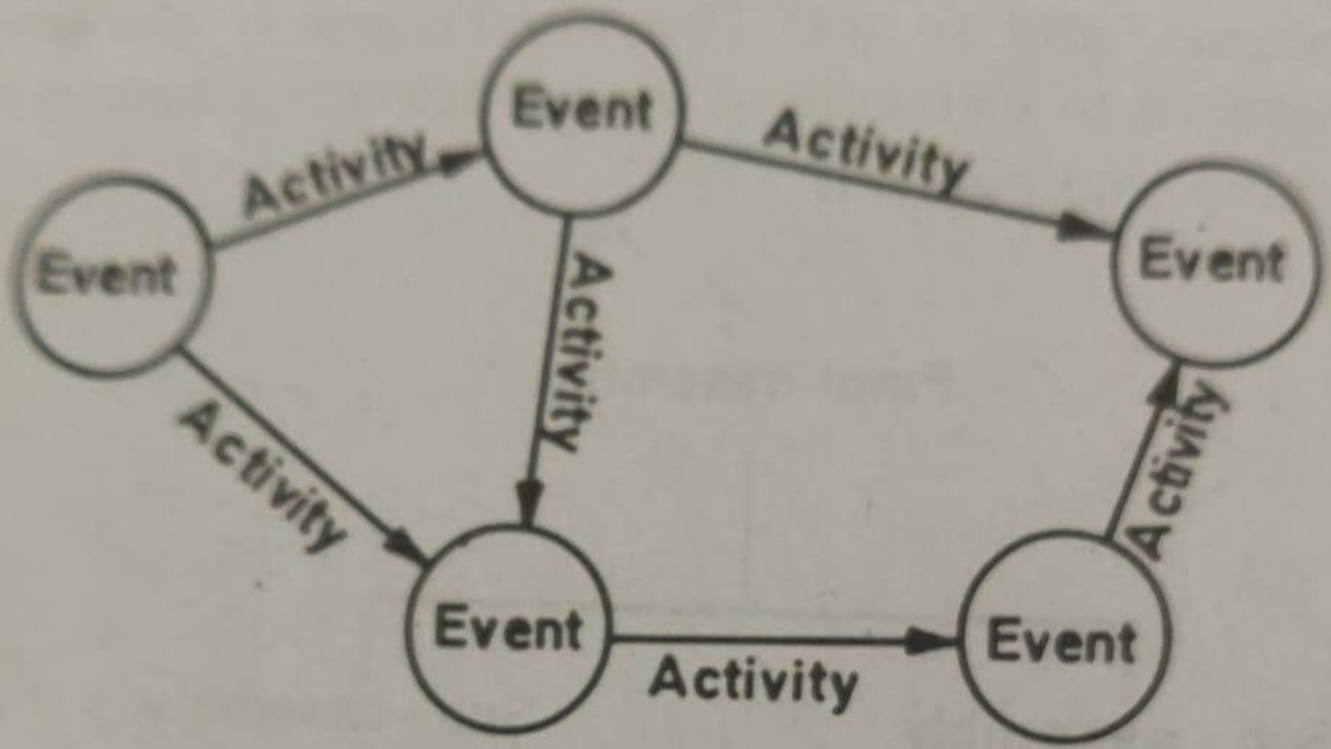
Event
Activity
Event
Activity
Event
Activity
Activity
Event
Activity
Event
Activity
Event

FIGURE 1-9

CPM AND PERT

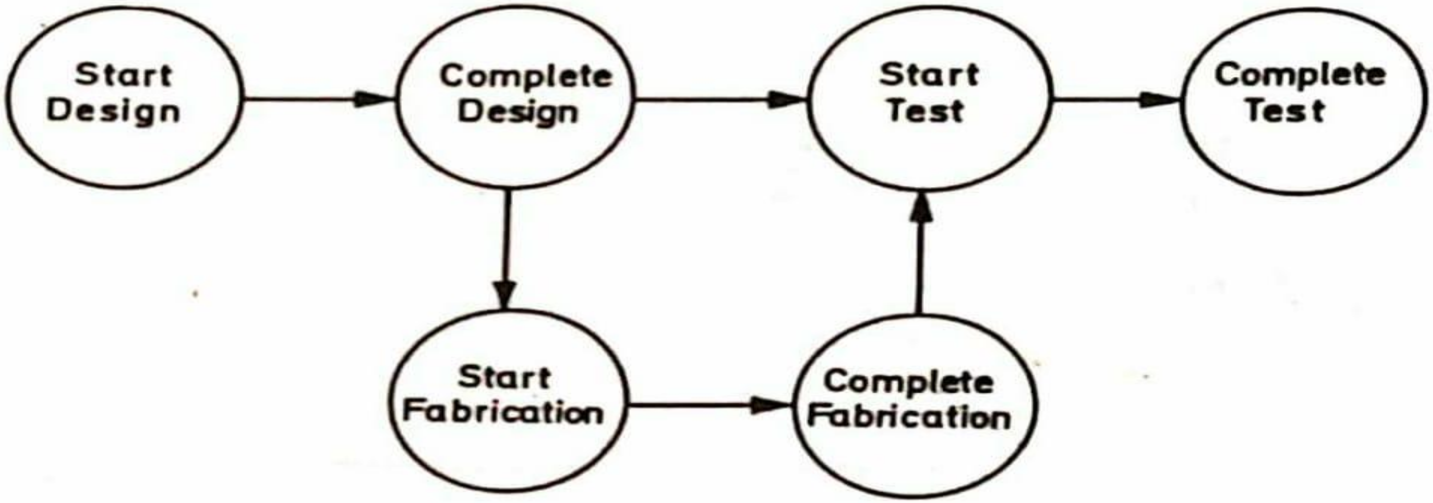

FIGURE 1-11

NETWORK TECHNIQUES

2.4 NUMBERING THE EVENTS

The event numbers should in some respect reflect their logical sequences. When a complicated network has been formed after numerous additions and deletions (which are unavoidable before a final acceptable network is obtained), the problem of assigning numbers to the events has to be considered. A rule devised by D. R. Fulkerson reduces this sequential numbering to the following steps:

(i) An "initial" event is one which has arrows coming out of it and none entering it. In any network, there will be one such such event. Number it "1".

(ii) Delete all arrows emerging from event 1. This will create at least one more "initial event".

(iii) Number these new initial events as "2, 3, . . .".

(iv) Delete all emerging arrows from these numbered events which will create new initial events.

(v) Follow step (iii).

(vi) Continue until the last event which has no arrows emerging from it is obtained.

Let us consider the network shown ...

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Let us consider the network shown

emerge. Deleting these, we get events E and J which have only emerging arrows. *Notice carefully that event K will have an arrow entering after deleting c and f, and hence cannot form initial events.* Number events E and J as 4 and 5, respectively.

(v) Delete arrows g, d, and h. These give events F and K which will be numbered 6 and 7, respectively.

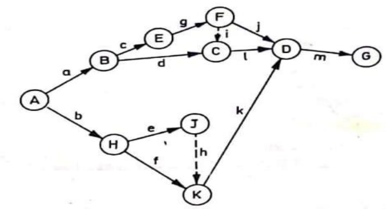

FIGURE 2-10

(vi) Delete arrows i, j, and k. Events C and D will get numbers 8 and 9, respectively.

(vii) Finally, Event G which has no emerging arrows will form the end event and is numbered 10.

The network with events numbered is shown in Fig. 2-11.

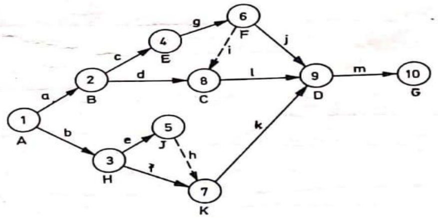

FIGURE 2-11

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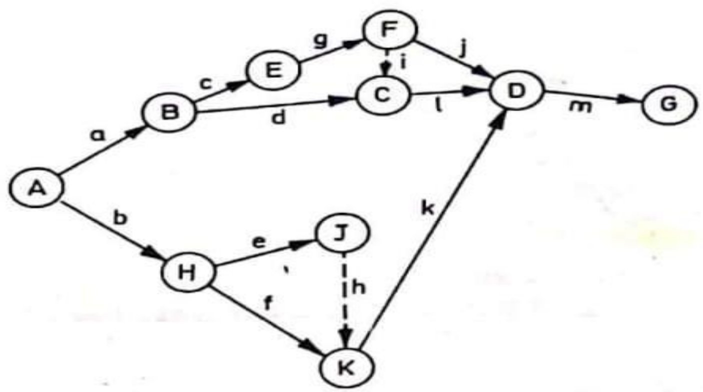

FIGURE 2-10

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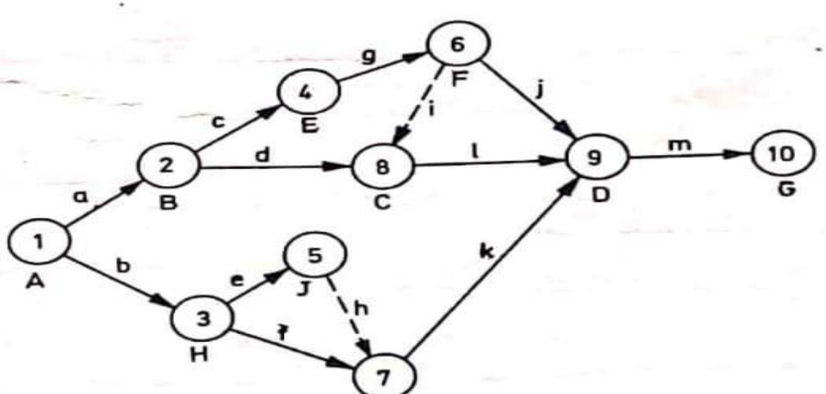

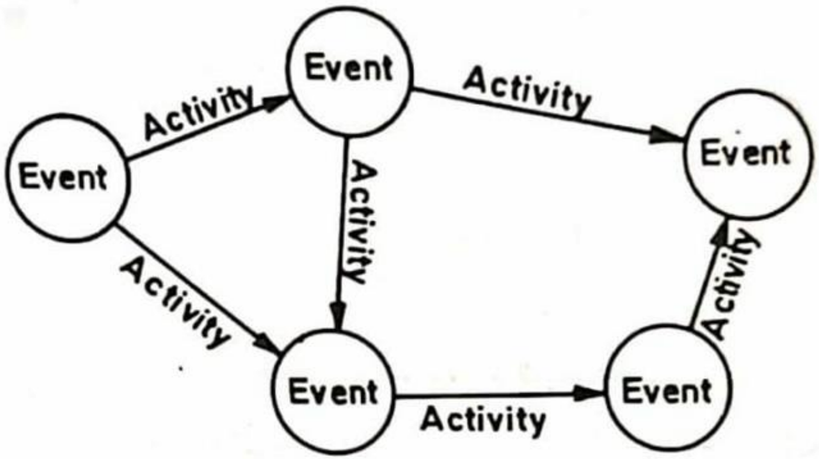
Event
Activity
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Activity
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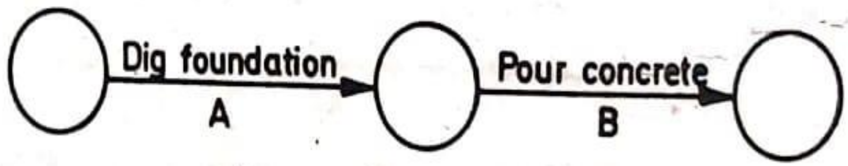
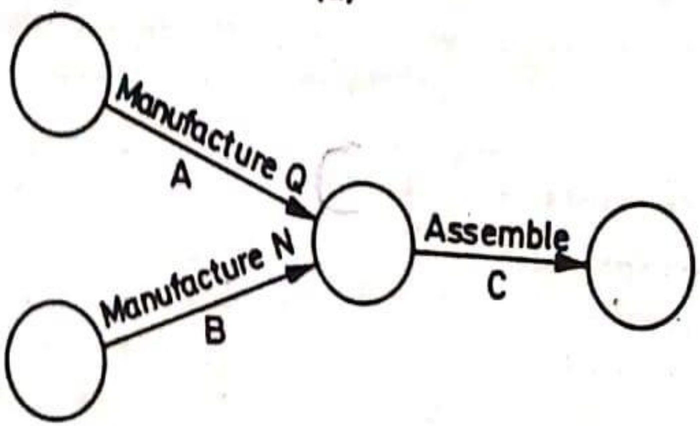
Activity
Activity
Activity
Event
Activity
Event
Activity
Event

FIGURE 1-9



(a)



(b)

FIGURE 1-10 (*cont.*)

PERT — event oriented

Hiresh Gupta

- there are activities for which the associated time duration can be accurately estimated

Activity

- Each activity takes some time duration for its completion
- this duration depends upon the nature of activity
- there are some activities which are performed rarely so no data of time exists for such activities
- their time duration is uncertain.
- such activities are called variable activities

ex: creative activities such as research, design & development work

Deterministic activities

1) there are some activities for which associated time can be estimated accurately are called deterministic type. these are repetitive in nature.

PERT	CPM
1) the projects which comprise of variable type activities associated with probabilistic time estimate employ PERT of network	1) Projects which consists of deterministic type of activities are handled by CPM.
2) PERT is event oriented	2) CPM is activity oriented
3) It is based on 3-time	3) it is based on single time estimate

estimates they are optimestic, pessimestic & most likely time

- PETR Takes in account uncertainity while estimating activity times

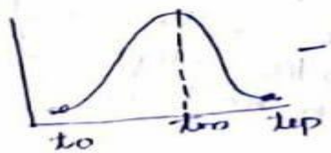
average time required to execute the activities.

4) To det. single time some historical data may be available or best way of predicting data is by intelligence guess. the experience of person his techniqueal knowdge

5) CPM does not take in to a/c the uncertaintity while estimating activity times

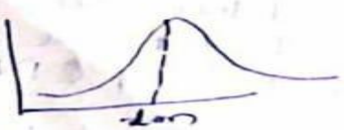
Frequency distribution curve for PERT activity

- we know three time estimates optimestic, pessimestic & most likely.
- In the range of optimestic to pessimestic time estimates, there can be number of time
- If the frequency distribution for these can plotted we get



- this is known as β - distribution curve.
- to & tp occurs at the end.
- tm - need not to be at the midpt

- the frequency distribution varies.



Mean (μ) & standard deviation (σ)

Chandrashekhar

Time estimates

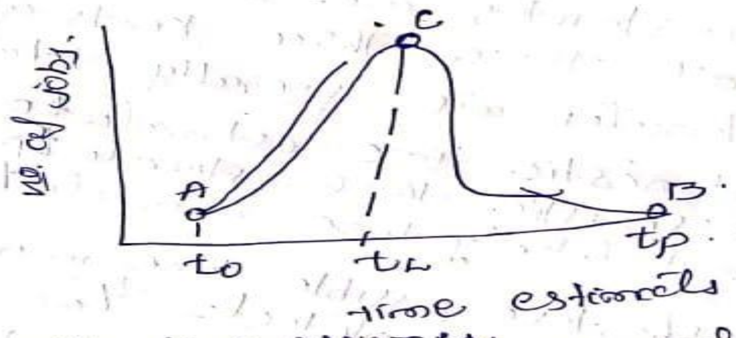
- after the planning is decided: next is time required for execution of each activity
- there is always pressure to do the job in short time.
- many uncertainties are there to account all these three kinds of time estimates are generally obtained.

1) The optimistic time estimate to
2) The pessimistic time estimate tp
3) The most likely time estimate tL

1) This is shortest possible time in which activity can be completed. – t_o
2) maximum possible time to complete the job.
   - considering abnormal situations
   t_p
3) – time estimate which lies between optimistic & pessimistic time estimate
   tL
   - it assumes that things go in normal way
   - things are usual.

- All three are selected in days week or months

- these 3 time estimates are given by person based on his experience & information
- there is relationship between these time estimates & this is given by frequency distribution curve



to - this time assumes: every thing goes according to plan & with minimum amount of difficulties.

tp - this time assumes that everything will not go according to plan & max potential difficulties will develop.

tL - this the time that is there in the functional manager

1) $\mu = \frac{t_o + 4t_m + t_p}{6}$

2) ~~[illegible]~~ Std. deviation $\sigma = \frac{t_p - t_o}{6}$

V is variance (uncertainty)

3) $V = \sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$

Expected time or average time of an activity is taken equal to mean.

4) $t_E = \mu = \frac{t_o + 4t_m + t_p}{6}$

What is the probability this ~~excepted time~~ activity will be completed in this excepted time?

- Varience is uncertainty.
- Greater the varience the larger is uncertainty

ex $t_o = 5$ days $t_m = 7$ days $t_p = 9$ days.

$t_E = \frac{5 + 4\times7 + 9}{6} = \frac{14 + 28}{6} = \frac{42}{6} = 7$ days.

$V = \left(\frac{9-5}{6}\right)^2 = 0.444.$

$t_o = 4$ $t_m = 7$ $t_p = 10$

$t_E = \frac{4 + 4\times7\times10}{6} = 7$ days

$V = \frac{10-4}{6} = 1.$

t_E remains same

comparing these two V is more in 2nd case — uncertainty of completion of activity is more in 2nd.

different, and for each path we can get three time estimates based
the optimistic, the most likely, or the pessimistic time estimate. These

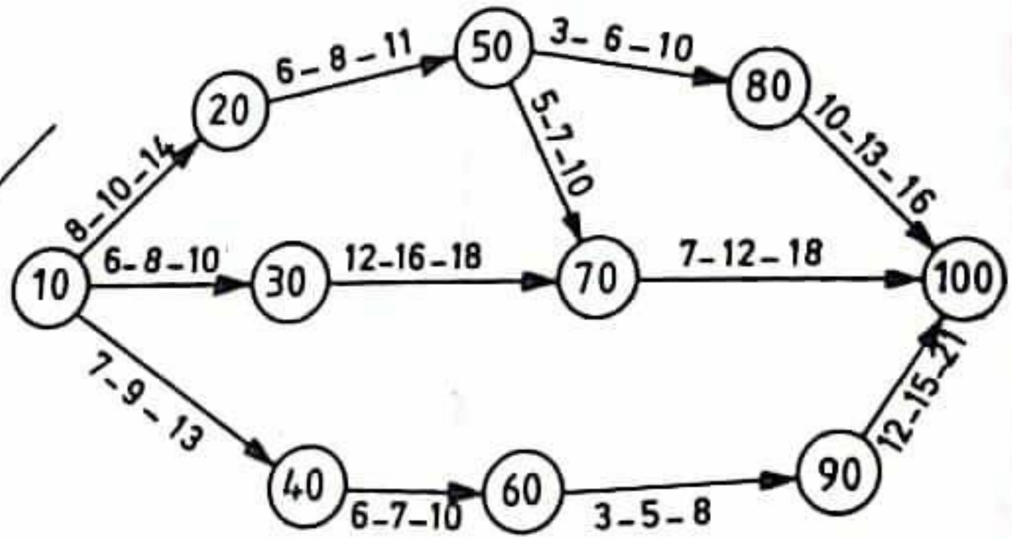


FIGURE 3-5

shown in Table 3-2.

TABLE 3-2

20–50. Proceeding this way, we arrive at events 70 and 80, the latter being the end event. The sequentially numbered network is shown in Fig. 3-9.

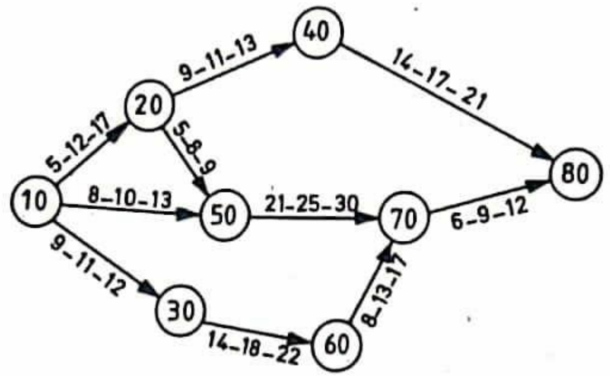


FIGURE 3-9

We shall now enter the data as shown in Table 3-4.

TABLE 3-4

Predecessor event	*Successor event*	t_O	t_L	t_P	σ^2	t_E
10	20	5	12	17	4.0	11.67
10	30	9	11	12	0.25	10.83
10	50	8	10	13	0.69	10.17
20	40	9	11	13	0.44	11.00
20	50	5	8	9	0.44	7.67
30	60	14	18	22	1.78	18.00
40	80	14	17	21	1.36	17.17
50	70	21	25	30	2.25	25.18
60	70	8	13	17	2.25	12.83
70	80	6	9	12	1.0	9.00

In entering the event numbers, first the number of the start event is

Figure 3-11 shows the network with events properly numbered.

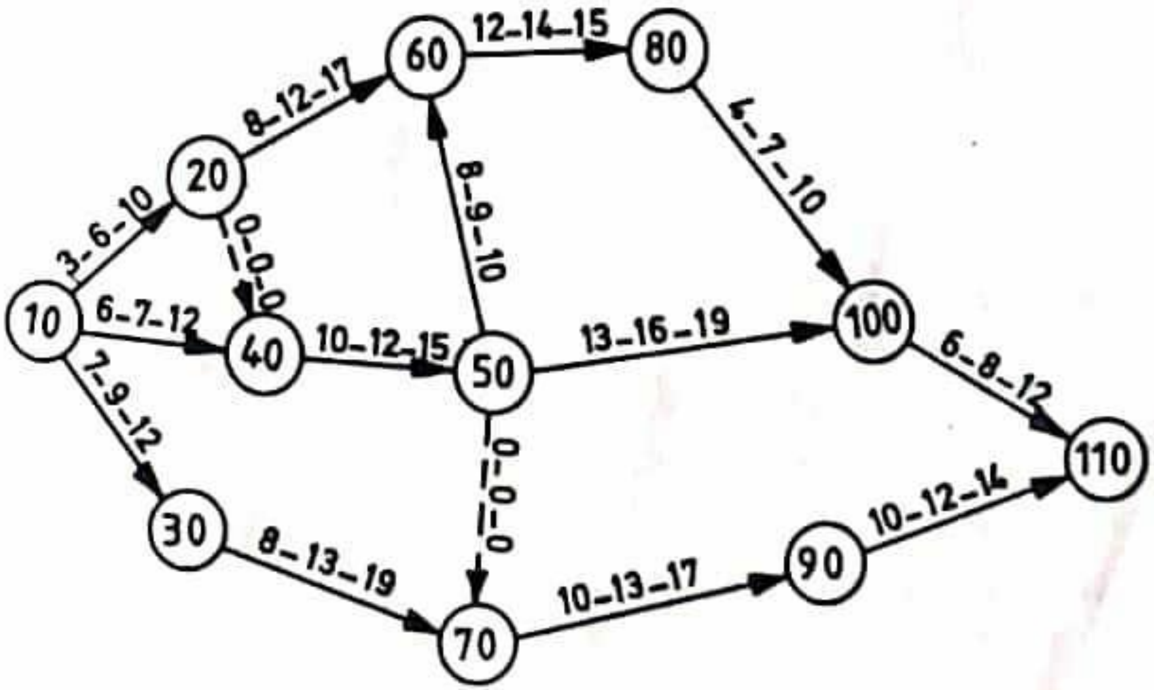


FIGURE 3-11

TABLE 3-5

Predecessor event	*Successor event*	t_O	t_L	t_P	σ^2	t_E
10	20	3	6	10	1.36	6.17
10	30	7	9	12	0.70	9.17
10	40	6	7	12	1.0	7.67
20	40	0	0	0	0.0	0.0
20	60	8	12	17	2.25	12.17
30	70	8	13	19	3.36	13.17
40	50	10	12	15	0.70	12.17
50	60	8	9	10	0.11	9.00
50	100	13	16	19	1.00	16.00
60	80	12	14	15	0.25	13.83
70	90	10	13	17	1.36	13.17
80	100	4	7	10	1.00	7.00
90	110	10	12	14	0.44	12.00
100	110	6	8	12	1.00	8.33

The predecessor and successor events are entered in a manner similar to that explained in Example 1. The other entries are straightforward.

QUESTIONS

4

Computation I

4.1 EARLIEST EXPECTED TIME

From the three time estimates, we are able to calculate the expected time or the average time which, in simple networks, enables us to find the critical path. But in large networks, a systematic method of determining the critical path or paths becomes a necessity. To achieve this, we need to calculate, for each *event*, two time estimates—the *earliest expected time*, which we shall discuss in this section, and the latest start time.

We should notice one important point here. The optimistic, most likely, and pessimistic time estimates, all refer to an *activity* or a *job*. The expected time or the average time t_E also refers to an activity connecting two events. However, both the earliest expected time and the latest start time refer to *events*.

The *earliest expected time*—denoted by T_E—refers to the time when an event can be expected to be completed. It is computed by adding the t_E's of the activity paths leading to that event. Let us consider the network shown in Fig. 4-1.

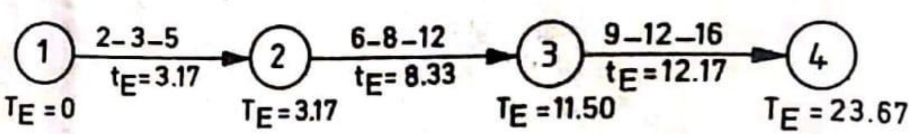


FIGURE 4-1

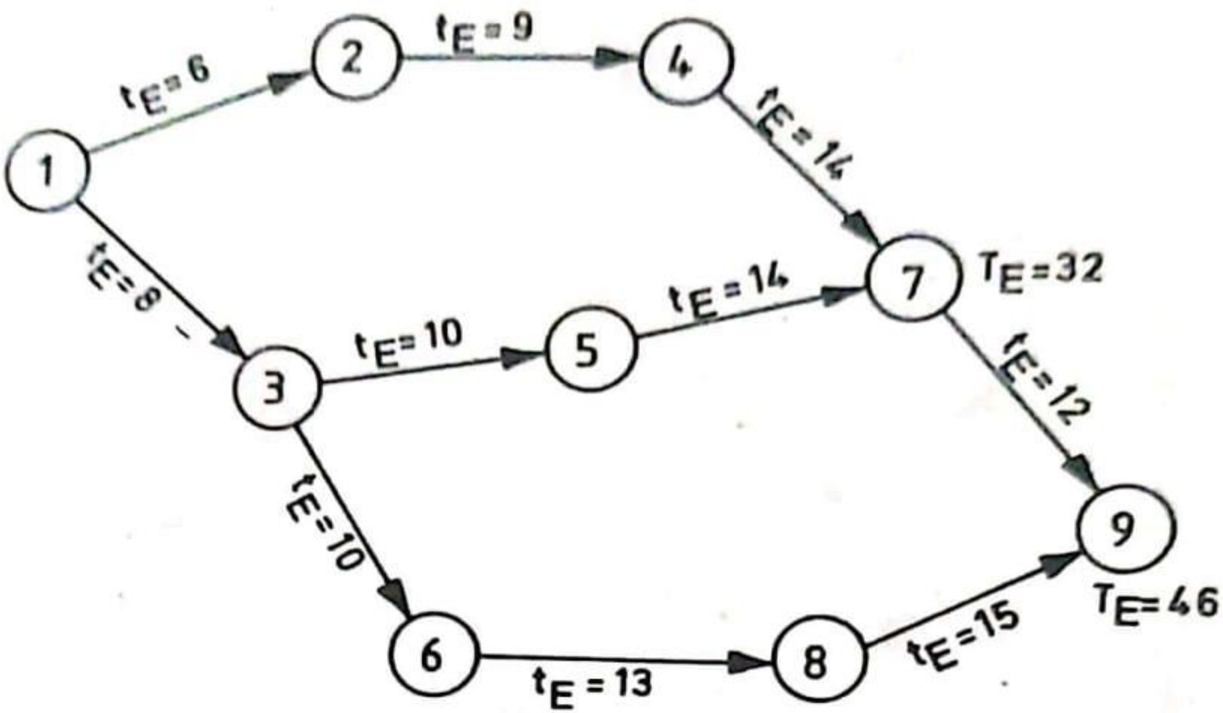

1
2
3
4
5
6
7
8
9
$t_E = 6$
$t_E = 9$
$t_E = 8$
$t_E = 14$
$t_E = 10$
$t_E = 14$
$T_E = 32$
$t_E = 10$
$t_E = 12$
$T_E = 46$
$t_E = 13$
$t_E = 15$

FIGURE 4-2

the predecessor and successor

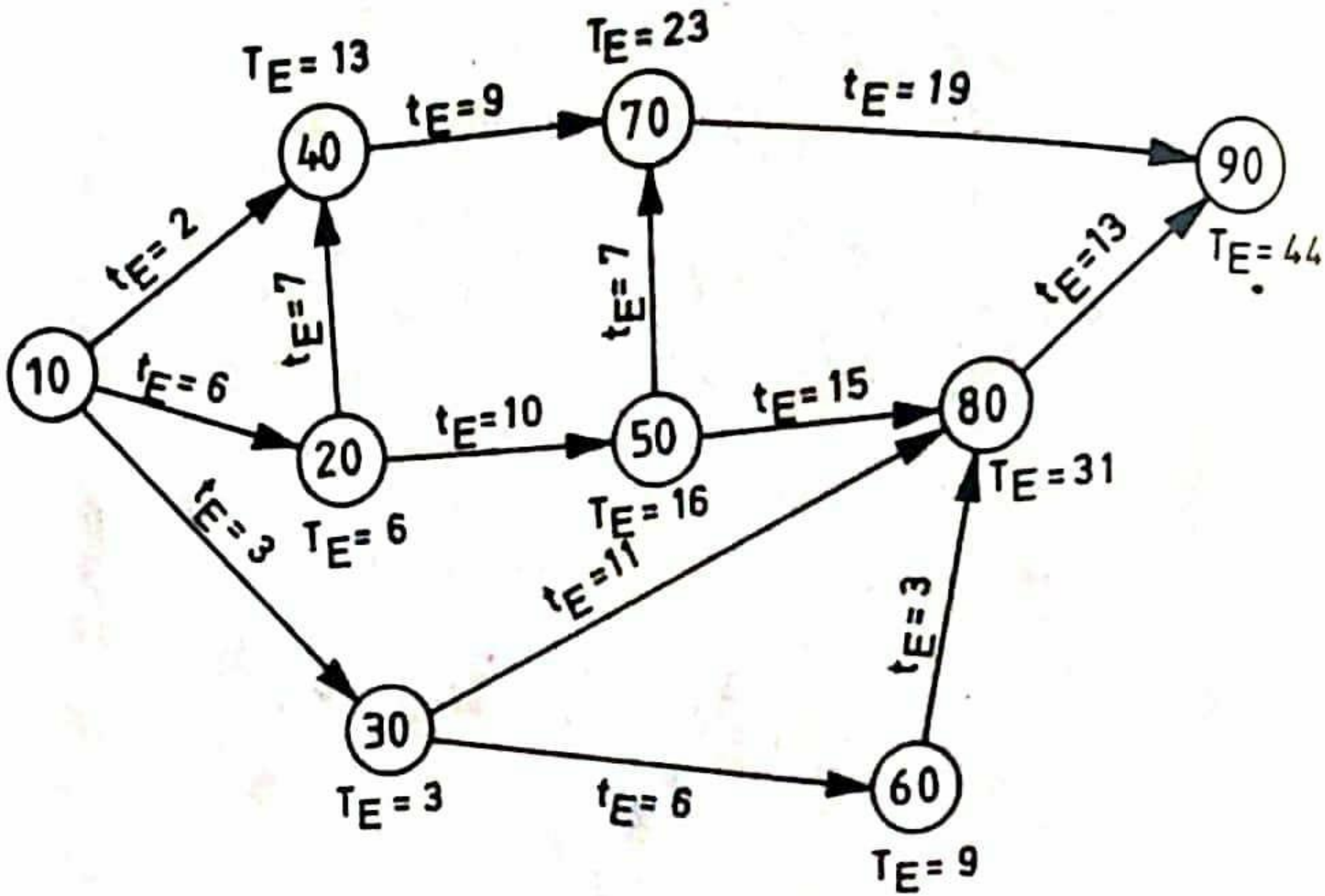


FIGURE 4-3

from the initial to the terminal event.

4.3 LATEST ALLOWABLE OCCURRENCE TIME

Here, we shall discuss the second time estimate regarding the event. The latest time by which an event must occur to keep the project on schedule is known as the *latest allowable occurrence time*, and is denoted by T_L. To explain this, let us assume that it has been agreed to complete the project within a certain allotted time called the *contractual obligation time*, denoted by T_S. This time refers to the occurrence of the end event. Let us consider once again the simple network already referred to in Fig. 4-1 and repeated in Fig. 4-4. Let us say that the contractual obligation time T_S for the project is 27. This means that the end event 4 must occur 27 units of time after the project is initiated.

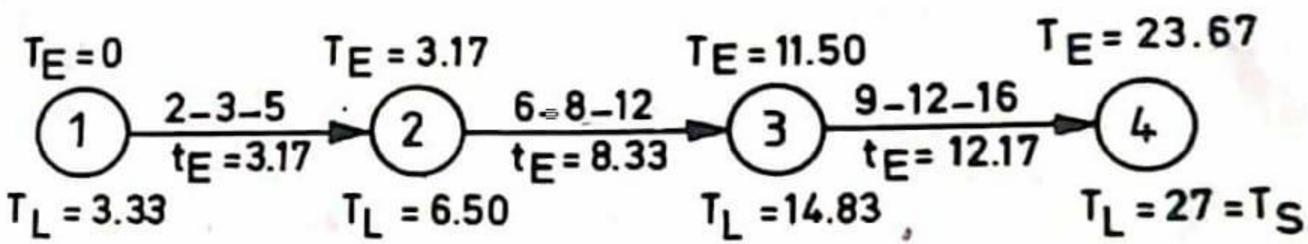


FIGURE 4-4

When an event has more than one successor event, more than one T_L will be available. Consider the network shown in Fig. 4-5.

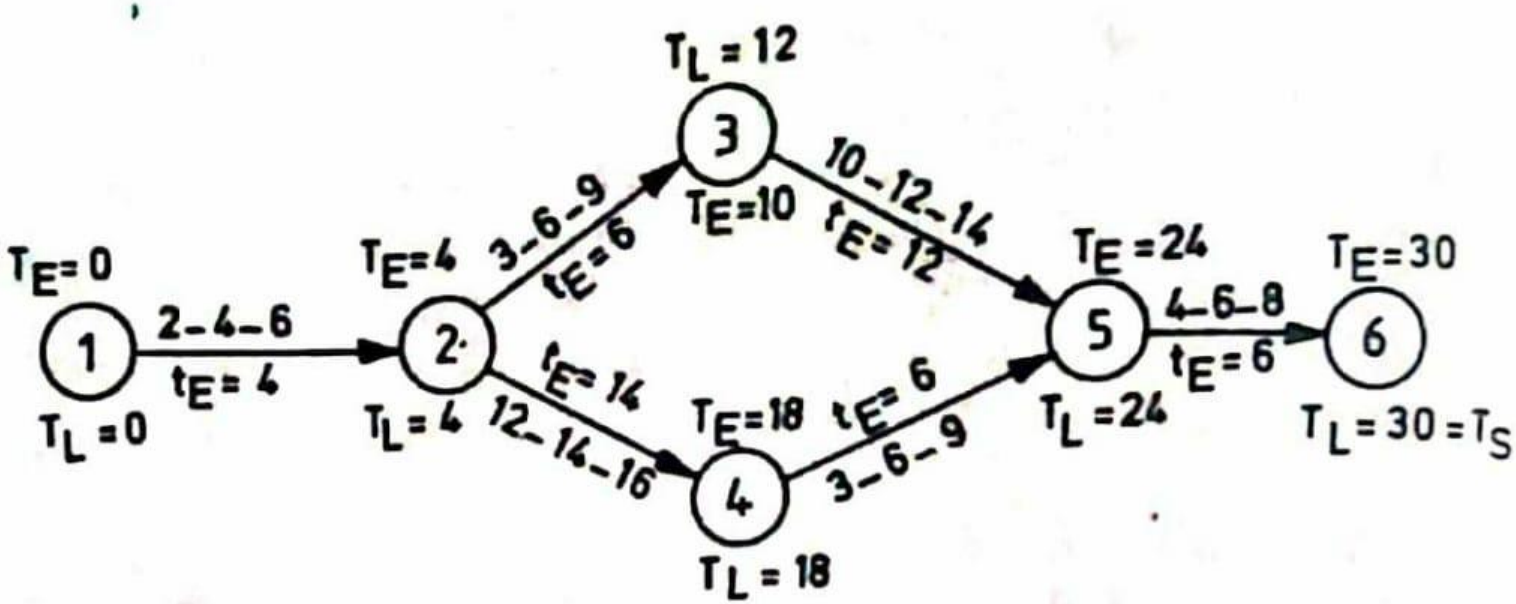
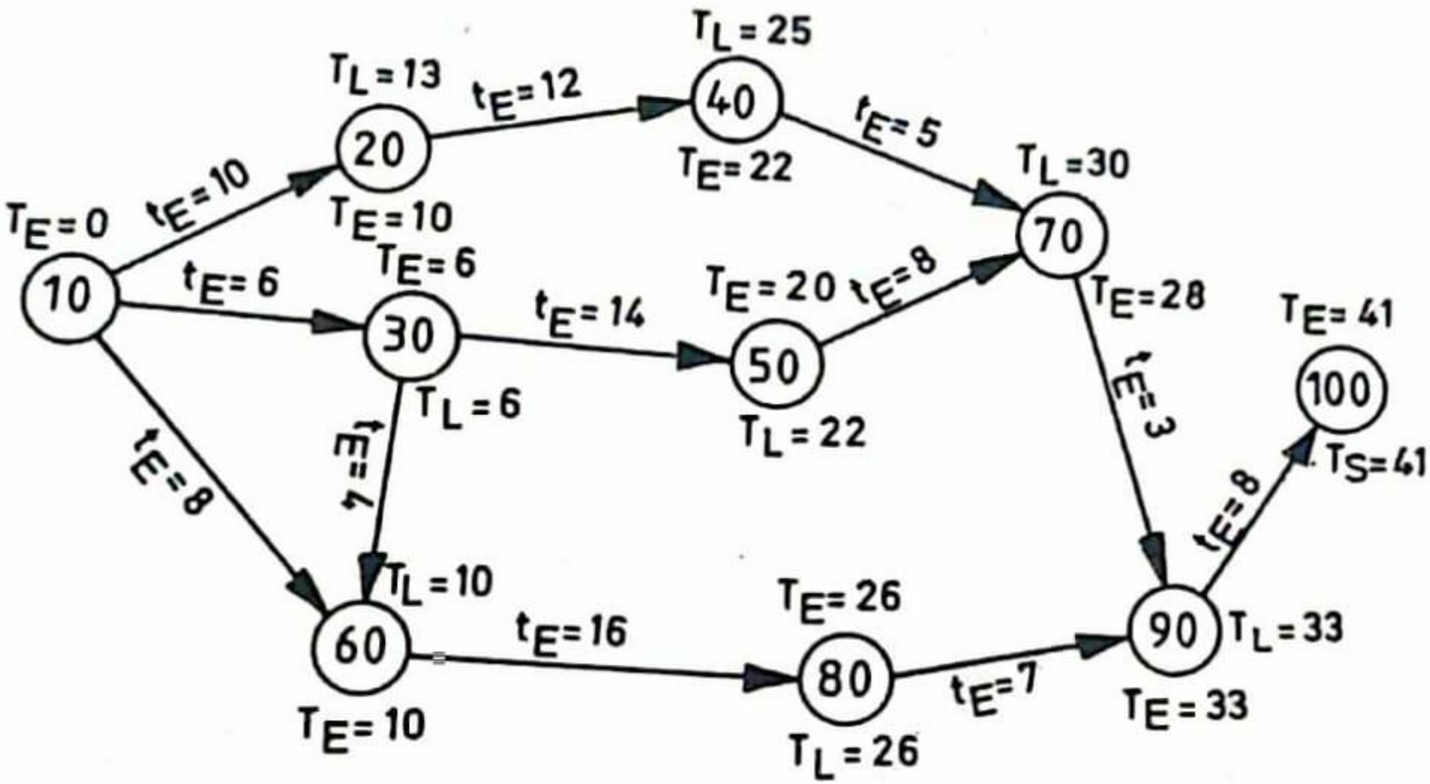


FIGURE 4-5



$T_L = 25$
$T_L = 13$
$t_E = 12$
40
$t_E = 5$
20
$T_E = 22$
$T_L = 30$
$t_E = 10$
$T_E = 0$
$T_E = 10$
70
$T_E = 6$
$t_E = 6$
$T_E = 20$
$t_E = 8$
10
$t_E = 14$
$T_E = 28$
$T_E = 41$
30
50
$t_E = 3$
100
$T_L = 6$
$T_L = 22$
$T_S = 41$
$t_E = 8$
$t_E = 4$
$t_E = 8$
$T_L = 10$
$t_E = 16$
$T_E = 26$
60
90
$T_L = 33$
80
$t_E = 7$
$T_E = 10$
$T_E = 33$
$T_L = 26$

FIGURE 4-6

PROBLEM 1

Design the Network for fallowing set of activities of project. Determine

i) Earliest Start

ii) Earliest Finish

iii) Latest start

iv) Lates Finish and Identify the critical path and project duration.

Job i-j	
Successor event j	Predecessor event i
100	90
90	80
90	70
80	60
70	50
70	40
60	30
60	10
50	30
40	20
30	10
20	10

Job i-j								
Successor event j	Predecessor event i	t_O^{ij}	t_L^{ij}	t_P^{ij}	t_E^{ij}	T_E^j	T_L^i	T_L^j
100	90	6	8	10	8	41	33	41
90	80	5	7	9	7	33	26	33
90	70	2	3	4	3	31	30	33
80	60	14	16	18	16	26	10	26
70	50	7	8	9	8	28	22	30
70	40	4	5	6	5	27	25	30
60	30	2	4	6	4	10	6	10
60	10	6	8	10	8	8	2	10
50	30	10	14	18	14	20	8	22
40	20	8	12	16	12	22	13	25
30	10	4	6	10	6	6	0	6
20	10	4	10	16	10	10	-3	13

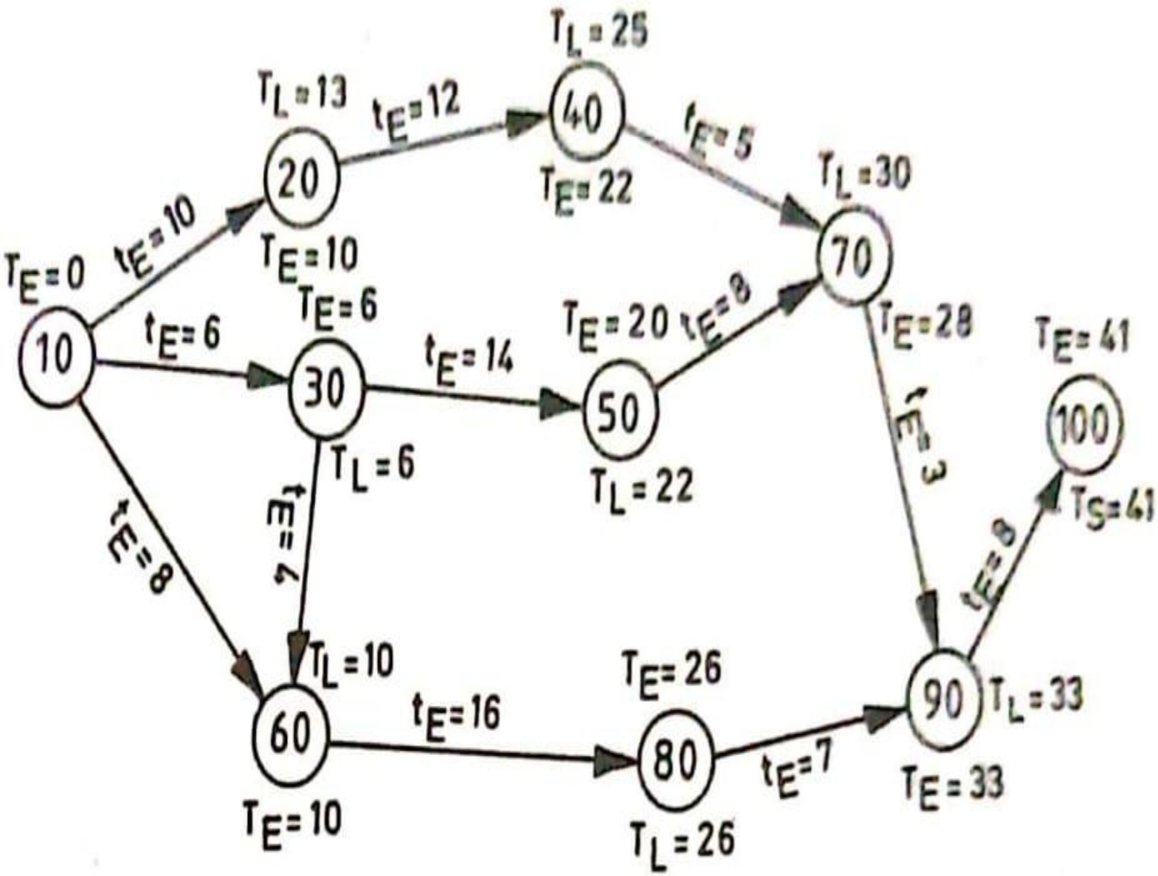


FIGURE 4-6

Job i-j								
Successor event j	Predecessor event i	t_O^{ij}	t_L^{ij}	t_P^{ij}	t_E^{ij}	T_E^j	T_L^i	T_L^j
100	90	6	8	10	8	41	33	41
90	80	5	7	9	7	33	26	33
90	70	2	3	4	3	31	30	33
80	60	14	16	18	16	26	10	26
70	50	7	8	9	8	28	22	30
70	40	4	5	6	5	27	25	30
60	30	2	4	6	4	10	6	10
60	10	6	8	10	8	8	2	10
50	30	10	14	18	14	20	8	22
40	20	8	12	16	12	22	13	25
30	10	4	6	10	6	6	0	6
20	10	4	10	16	10	10	3	13

Job i-j								
Successor event j	Predecessor event i	t_O^{ij}	t_L^{ij}	t_P^{ij}	t_E^{ij}	T_E^j	T_L^i	T_L^j
100	90	6	8	10	8	41	33	41
90	80	5	7	9	7	33	26	33
90	70	2	3	4	3	31	30	33
80	60	14	16	18	16	26	10	26
70	50	7	8	9	8	28	22	30
70	40	4	5	6	5	27	25	30
60	30	2	4	6	4	10	6	10
60	10	6	8	10	8	8	2	10
50	30	10	14	18	14	20	8	22
40	20	8	12	16	12	22	13	25
30	10	4	6	10	6	6	0	6
20	10	4	10	16	10	10	3	13

6.12 FLOAT

In the previous few sections, we considered the time elements associated with events. The next point of interest is the activities and their start and finish times. We can define the following for a given activity *i-j*:

Earliest Start Time This is the earliest occurrence time for the event from which the activity arrow originates, i.e., T_E^i.

Earliest Finish Time This is the earliest occurrence time for the event from which the activity arrow originates plus the duration for the activity, i.e., $= (T_E^i + t^{ij})$.

TF

The total duration of time available for any job is the difference between its earliest start time and latest finish time. If *i-j* is the job under consideration, then

$$\text{maximum time available} = T_L^j - T_E^i.$$

If job *i-j* requires only t^{ij} units of time for its execution, the *total float* for job *i-j* is the difference between the maximum time available for the job and the actual time it takes, that is,

$$\text{total float for } i\text{-}j = (T_L^j - T_E^i) - t^{ij}$$
$$= (T_L^j - t^{ij}) - T_E^i.$$

We notice this is equal to the latest start time for the activity minus its earliest start time. This value is obtained by taking the difference between the values given in the sixth and fourth columns.

The second type of float defined is the "free float" for an activity. This is based on the possibility that all events occur at their earliest times, i.e., all activities start as early as possible. Consider two activities *i-j* and *j-k* where the second activity *j-k* is a successor activity to *i-j*. Let the earliest occurrence time for event *i* be T_E^i and for event *j*, T_E^j. This means that the earliest possible start time for activity *i-j* is T_E^i, and for activity *j-k*, it is T_E^j. Let the duration for activity *i-j* be t^{ij}. Assume that *i-j* starts at T_E^i and takes t^{ij} units of time, and that the next activity *j-k* cannot start because its earliest possible start time T_E^j is greater than $(T_E^i + t^{ij})$. Then,

$$T_E^j - (T_E^i + t^{ij})$$

10 - (0+10
=
4 - (0+4)

is called the *free float* for activity *i-j*, i.e.,

$$\text{free float for } i\text{-}j = T_E^j - (T_E^i + t^{ij})$$

= 4 - 4 = 0

$$= T_E^j - \text{earliest finish time for } i\text{-}j.$$

12 - (0+12)

$= T_E^j -$ earliest finish time for *i-j*.

We can restate this as follows: 12 − (0 + 12)

The free float for activity i-j is the difference between its earliest finish time and the earliest start time for its successor activity. = 0

For example, in Table 6-2, the earliest finish time for activity 5-7 is 20 and the earliest start time for its successor activity 6-7 or 6-8 is 22. Hence, the free float for activity 5-7 is 2. The values for free float have been entered in column nine.

Another type of float, termed the "independent float", is also defined. Its basis is as follows. Let *i-j* be the activity of interest and *h-i* and *j-k*, respectively, be its predecessor and successor activities (Fig. 6-14). Let the preceding job *h-i* finish at its latest possible moment, which is T_L^i, and the succeeding job *j-k* start at its earliest possible moment, which is

T_L^j T_E^j

FIGURE 6-14

T_E^j. Then, activity *i-j* can take up any duration from t^{ij} to $(T_E^j - T_L^i)$ without in any way affecting the network. The difference between $(T_E^j - T_L^i)$ and t^{ij} is called the *independent float*, i.e.,

$$\text{independent float for } i\text{-}j = (T_E^j - T_L^i) - t^{ij}.$$

Consider activity 6-8 shown in the network of Fig. 6-13 redrawn partially in Fig. 6-15.

The latest finish time for the job preceding 6-8 is 22 and the earliest

TABLE 6-2

(1) Job i	(2) j	(3) Duration t_{ij}	(4) Earliest Start T_E^i	(5) Earliest Finish T_E^j	(6) Latest Start T_L^i	(7) Latest Finish T_L^j	(8) Total float TF	(9) Free float FF	(10) Independent float IF
1	2	4	0	4	0	4	0	0	0
1	3	12	0	12	2	14	2	0	0
1	4	10	0	10	2	12	2	2	2
2	4	8	4	12	4	12	0	0	0
2	5	6	4	10	6	12	2	0	0
3	6	8	12	20	14	22	2	2	0
4	6	10	12	22	12	22	0	0	0
5	7	10	10	20	12	22	2	2	0
6	7	0	22	22	22	22	0	0	0
6	8	8	22	30	24	32	2	2	2
7	8	10	22	32	22	32	0	0	0
8	9	6	32	38	32	38	0	0	0

IF

TF